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Vein Graft Stenosis: Incidence and Intervention

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Objectives: *The incidence of vein graft stenosis ranges from 5%–45%. Reported rates appear to be increasing as technological advances make detection easier. The aim of this study was to review our experiences with regard to the incidence of stenosis in infrainguinal bypass grafts and the outcome of intervention for salvage of failing grafts.*
Design: *Retrospective review of graft surveillance records.*
Setting: *Vascular Studies Unit, Bristol Royal Infirmary.*
Methods: *A Duplex-based graft surveillance (GS) programme was used from January 1989 to June 1994 to study 275 primary graft procedures in 250 patients with lower limb ischaemia. Patients were scanned at 1 week, 6 weeks and 3, 6, 9 and 12 months postoperatively.*
Results: *One year cumulative limb salvage, patient survival and primary, primary assisted and secondary patencies were 91%, 83%, 67%, 77% and 84% respectively. Duplex scanning detected 85 vein graft stenoses in 59 patients: an incidence of 21.5%. In addition, 64 potentially graft-threatening inflow (14) and outflow (50) problems were detected in the native vessels of 52 patients from clamp damage or progression of disease (POD).*
Of the 85 graft stenoses, 40 were treated by balloon angioplasty (PTA) and 20 by surgical intervention and 1 patient's symptoms were treated by chemical sympathectomy. Twenty-four patients were not actively treated. Of the 64 grafts affected by POD, 20 were treated by PTA, 15 by surgery, one with anti-coagulation and 28 had no treatment. Comparing patients with non-treated and treated lesions, the respective 12 month cumulative patencies for patients with graft stenoses were 75% and 87.5% as against 86% and 83% for patients with POD (log rank test : $p > 0.1$).
Conclusions: *These results uphold the perceived benefits of a GS programme, although the evidence from the non-treated cases in this series reinforces a need for a large, prospective, randomised trial to confirm the case for GS.*

Key Words: Graft surveillance; Graft stenosis; Intimal hyperplasia.

Introduction

Ever since Szilagyi studied the biological fate of femoropopliteal bypass grafts and reported the development of fibrous strictures due to intimal hyperplasia in nearly 30% of vein grafts,[1] postoperative graft surveillance (GS) programmes have been advocated for the detection of stenotic lesions which when treated appropriately may salvage the "at risk" graft from occlusion.[2,3] GS is justified if progression from stenosis to occlusion is inevitable and if intervention prolongs graft survival. Other causes of graft failure include technical errors and dysplastic, narrowed segments in non-compliant, thickened, post-phlebitic veins of substandard quality.

The proponents of GS draw evidence from the growing literature reporting impressive secondary patencies following intervention.[2,4–9] Moody *et al.* reported significantly enhanced cumulative patencies when comparing a group of screened grafts with historical controls for whom GS was unavailable[2] but, to date, there has been only one small, prospective, randomised trial on GS comparing two different surveillance programmes (with and without duplex scanning).[10] The Swedish group studied patients for 3 years following surgery and reported the comparative patency rates following intervention, finding in favour of the Duplex GS regimen.[10]

The true incidence of vein graft stenosis remains uncertain ranging from 5%[11] to 45%.[12] It is generally accepted that follow-up should be most intense during the first year and that sensitive, reproducible, non-invasive methods are superior to clinical scrutiny on the one hand and preferable to arteriography on the other hand.[3] However, there are no standardised regimens for GS and there have been no large, prospective, randomised trials to compare the results

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of GS with no surveillance. In consequence, the criteria used to diagnose "at risk" grafts, the optimal technique for surveillance and the best method of intervention are widely debated.[13] There is also controversy as to the natural history of untreated vein graft stenoses.

This retrospective study was undertaken to review our 5 year experience with the GS programme at Bristol Royal Infirmary, with particular interest in the incidence of stenosis in this series and the outcome of intervention for salvage of failing grafts.

Material and Methods

A GS programme has been operational in this Unit since 1989. Between then and June 1994, 275 primary grafts in 250 consecutive patients (80% male, 37% diabetic) were recruited onto the programme. Sixty-two per cent of grafts were for limb threatening critical ischaemia, 35% for severe, limiting claudication (exercise tolerance less than 100 yards) and 3% were for asymptomatic, but enlarging popliteal aneurysms. Ninety-seven grafts were anastomosed onto the above-knee popliteal artery, the remainder were infrageniculate (71 distal/pedal grafts). Vein was the conduit of choice for 251 grafts (149 *in situ*, 60 reversed, 27 non-reversed, 4 arm vein and 11 composite) and polytetrafluoroethylene was used in the remaining cases. Postoperatively, patients were maintained on daily low-dose Aspirin.

Scanning was initially carried out using a black and white Technicare Autosector Duplex scanner (Technicare Corporation, Cleveland, Ohio, U.S.A.). In 1990, this was replaced by an ATL Ultramark 9 colour Duplex scanner (Advanced Technology Laboratories, Stevenage, U.K.) and in October 1992, the HDI upgraded version was installed. An "at-risk" graft was defined as one with slow flow, designated by peak mean velocities (PMV) less than 45 cm/s, a fall of at least 0.1 in the ankle-brachial Doppler pressure index (ABPI) and/or a focal velocity disturbance, designated by a V_2/V_1 ratio greater than 2.0 (where V_2 is the peak systolic velocity at a stenosis and V_1 is the peak systolic velocity at any other non-stenosed point within 2cm).

Duplex scans were performed at 1 week, 6 weeks and 3, 6, 9 and 12 months postoperatively, using a 5MHz linear array transducer to record PMV's along the graft. At each visit, symptoms, smoking habit and medication and resting Doppler ABPI's were recorded. Additional visits for more intensive surveillance were arranged at the discretion of the scanning technologist according to findings and a policy of open self-referral was adopted for patients developing symptoms between scheduled visits in order to avoid delay in the face of a critical stenosis or recent thrombosis.

Patients with Duplex-detected stenoses underwent arteriography and treatment of suitable lesions by percutaneous balloon angioplasty (PTA) at the discretion of the radiologist. PTA was the treatment of choice for short, discrete lesions, particularly in the body of the graft. In the event of a lesion being unsuitable for PTA, a patch angioplasty, an interposition graft or a jump graft were performed as appropriate.

The GS records and medical case-notes of all patients involved in GS during the study period were reviewed to investigate the incidence of vein graft stenosis and to evaluate the influence of intervention. Cumulative patency and life-table data were analysed according to the methods recommended by the Ad Hoc Committee on Reporting Standards.[14]

Results

The mean follow-up for this series was 10.5 months (range 2 weeks–48 months). Eighty-five vein graft stenoses were detected in 59 patients by Duplex scanning (≥ 50% stenosis) and subsequently confirmed by arteriography, an incidence of 21.5%. Stenoses were detected at a mean follow-up of 6.9 months (range 1 week–30 months). Thirteen stenoses (15.2%) developed at the 12 month stage or later. Treatment for graft stenoses is shown in Table 1.

Radiologically-successful PTA resulted in a median rise in the ABPI of 0.25 (range 0.06–0.46). Successful surgical intervention resulted in a median rise in the ABPI of 0.34 (range 0.00–0.76). Of 40 stenoses treated by PTA, 12 recurred and warranted further intervention : four were treated by surgery and eight by repeat PTA, supplemented by stent insertion in four cases. These re-do PTA's were successful for the remainder of the GS (median follow-up interval 10

Table 1. Modes of intervention for salvage of threatened grafts

	Number of lesions	PTA	Surgical	Sy	A/C	No treatment
Stenosis	85	40	20	1	0	24
POD	64	20	15	0	1	28

PTA=percutaneous transluminal angioplasty; Sy=sympathectomy; A/C=anti-coagulants; POD=progression of atherosclerosis in native vessels.

months; range 2–21 months) and there were no complications attributable to PTA alone.

In addition, 64 potentially graft-threatening problems in 52 patients were detected in the native vessels either proximal or distal to the graft due to progressive atherosclerotic disease (POD). For the majority of these grafts, POD was attributable to the outflow tract, but in 14, there were inflow problems. Treatment for POD is also shown in Table 1. Thirteen (20%) of the 64 lesions due to POD occurred at 12 months or later.

The 12 month limb salvage, patient survival and primary, primary assisted and secondary cumulative patencies were 91%, 83%, 67%, 77% and 84% respectively. The life table analyses are shown in Fig. 1. There was a significant difference between the primary and primary assisted and the primary and secondary patencies at 12 months ($p < 0.001$ using the log rank test). The respective 3 year limb salvage, patient survival and primary, primary assisted and secondary cumulative patencies were 86%, 68%, 49%, 59% and 69%.

Despite meeting the criteria for "at risk" grafts outlined above, 24 of the 85 graft stenoses and 28 of the 64 lesions due to POD were not treated for various reasons, including unacceptably high risk of intervention over conservative management, loss of all named run-off vessels, compromised patient fitness and refusal by the patient to consent to proposed treatment. Whilst accepting that these non-randomised groups may not be directly comparable, nevertheless, both non-treated and treated grafts fulfilled the designated Duplex criteria. The respective 12 month primary cumulative patencies for non-treated and treated patients with graft stenoses were 75% and 87.5% respectively (Fig. 2a) and for patients with grafts threatened by POD, they were 86% and 83% respectively (Fig. 2b). (For both Figs. 2a and b, the numbers represent patients with potentially "at risk" grafts at the beginning of each time interval rather than numbers of lesions. Numbers at 36 months were too small to be meaningful). For both stenoses and POD, there were no significant differences in the 12 month cumulative patencies for patients treated conservatively or actively ($p > 0.1$ using the log rank test).

Discussion

These results are in keeping with other published series[2,4,7–9] and uphold the benefits of GS programmes, with significantly enhanced primary assisted and secondary cumulative patency rates when compared with primary patencies in the same series. The incidence of vein graft stenosis of 20% is also in keeping with many other published series[2,8,15,16,18] although direct comparisons are diffi-

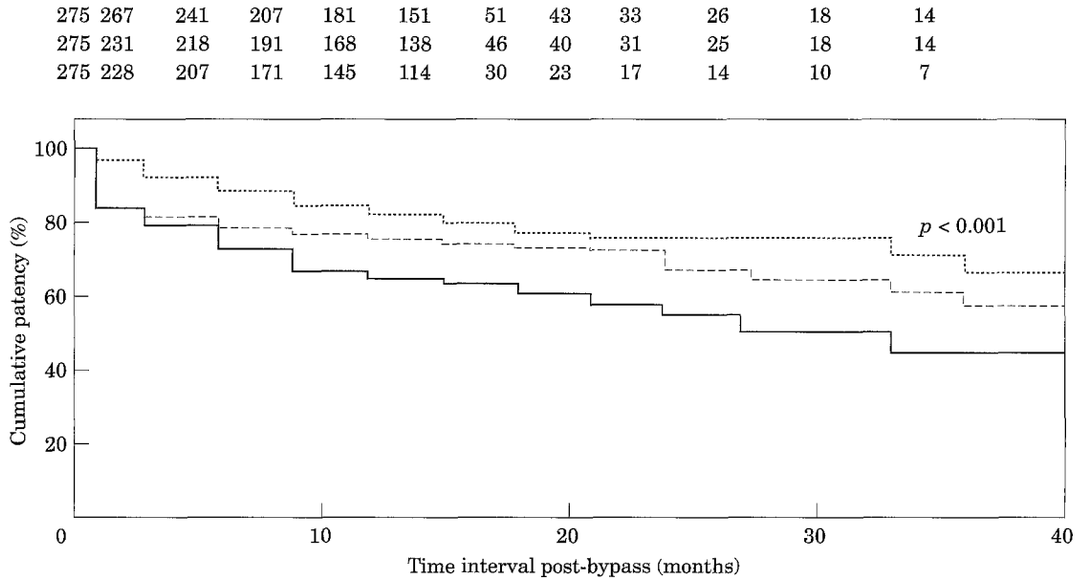

Fig. 1. Life-tables showing primary, primary-assisted and secondary patencies for the series. ($p < 0.001$ refers to the significant difference between primary and primary-assisted cumulative patencies and between primary and secondary cumulative patencies using the log rank test. Numbers above chart represent numbers of grafts at risk at the beginning of each interval and refer to secondary, primary-assisted and primary patencies respectively, reading from top to bottom). (—) primary patency; (- - -) primary assisted patency; (....) secondary patency.

cult due to the marked lack of standards in reporting on all aspects of GS.

When reviewing the literature, the variation in the recommended regimens, criteria and modes of intervention are striking. The ideal GS method should be non-invasive, simple, reproducible, cost-effective and highly sensitive and specific. Some series have relied solely on clinical examination and serial measurements of ABPI's,[6] others use ABPI's and Duplex scanning,[7,16,17] ABPI's, Duplex and digital subtraction arteriography[2,18] and Duplex alone.[8,19] Unfortunately, simple ABPI's have been shown to be unreliable, since the presence of graft-threatening stenoses is underestimated. In Cohen's series, which relied on ABPI's alone, there was a stenosis incidence of only 9%.[6] Wolfe *et al.* found that ABPI's failed to detect up to 50% of arteriographically proven stenoses[20] and Barnes *et al.* found that patients developing a drop in resting ABPI of more than 0.2 were at no greater risk of graft failure than patients with stable ABPI's following surgery.[21] Taylor *et al.* claimed almost perfect sensitivities and specificities for Duplex when using the simultaneous criteria of $V_2/V_1 > 2.0$ and PMV < 45 cm/s, as used in this study,[19] whilst Sladen *et al.* also recommended combined use of Duplex-derived low and high velocity criteria, but used a V_2/V_1 ratio of 3.0 or more to distinguish stenoses of between 60% and 80%.[22] In an earlier report from our group, Davies *et al.* compared ABPI's, Duplex scanning and impedance analysis and concluded that colour Duplex was the most sensitive, non-invasive modality for detection of stenoses as long as velocity ratios and absolute velocity measurements were considered together.[13]

The frequency of surveillance visits is also highly variable, the initial scan ranging from 1 week,[3,10] to 1 month,[9,13] 6 weeks[19] and 3 months[20] following surgery and the programme continuing for up to 9 months,[3] 12 months[2,11,19] and 3 years.[10] As the majority of intimal hyperplastic lesions appear between 1 and 12 months postoperatively, most regimes intensify GS during this interval, but even here, there are variations in accepted practice with

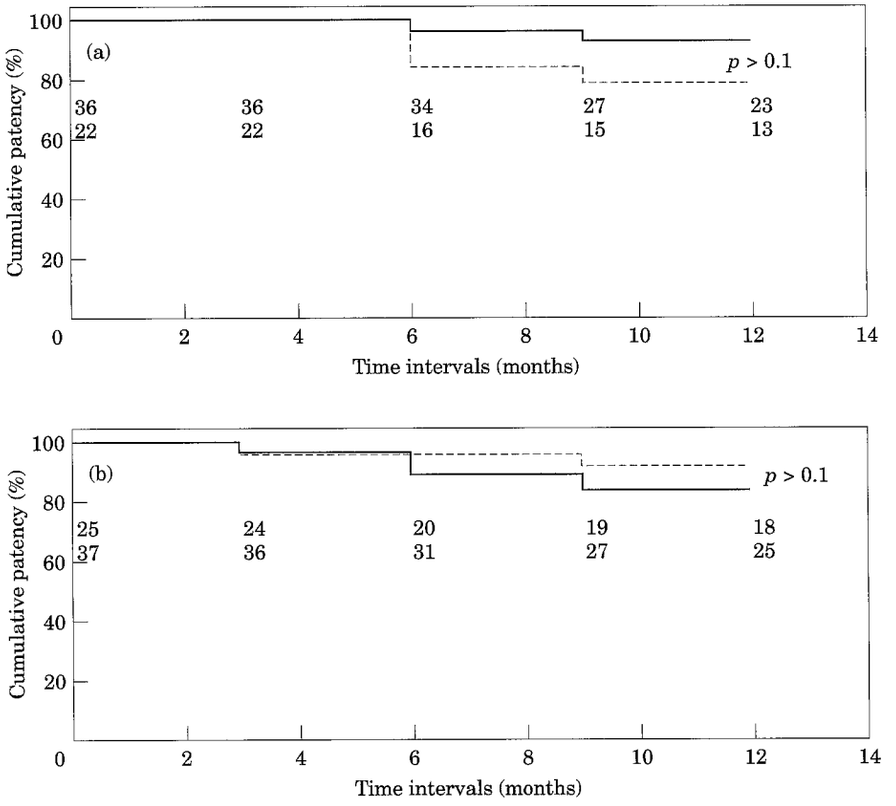

Fig. 2. (a) Life-tables showing 12 month cumulative patencies for patients with non-treated and non-treated graft stenoses. Numbers represent grafts at risk at beginning of each interval and refer to treated and non-treated grafts respectively, reading from top to bottom. (—) treated stenosed grafts; (- - -) non-treated stenosed grafts. (b) Life-tables showing 12 month cumulative patencies for patients with non-treated and treated grafts threatened by progression of disease in either inflow or outflow vessels. (Numbers represent grafts at risk at beginning of each interval and refer to non-treated and treated grafts respectively, reading from top to bottom). (—) treated grafts + POD; (- - -) non-treated grafts + POD.

some programmes reviewing patients 3 monthly[2,11] and some 6 monthly.[17] The graft stenoses and the cases of POD in native vessels which developed after 12 months and accounted for 17% of the total number of detectable lesions in this series raise the question as to whether GS should be extended beyond 12 months. A prospective, randomised trial might help to clarify this issue.

The recurrence of symptoms and the progression from stenosis to occlusion[15] are the rationale for GS and the justification for intervention. This view is supported by the poor results of revising a thrombosed graft compared to salvaging a functioning, albeit threatened bypass.[4,6,7,23,24] However, the lack of a significant difference between the treated and non-treated grafts in both the stenosis and POD groups in this series calls into question the inevitability of stenosis progression and raises the issue of possible unnecessary treatment, although it is accepted that overall numbers are small and these findings may represent a Type II statistical error. There is little data available on the natural history of untreated, asymptomatic but, haemodynamically significant lesions.[17] The occasional long-term success of conservative treatment in patients with poor haemodynamic indices[25] suggests that some stenoses may adopt a benign course and may not warrant intervention. By contrast, the occurrence of graft occlusion without warning despite regular surveillance suggests that some stenotic lesions are more aggressive or that some grafts fail for reasons other than stenosis or POD, such as poor cardiac output with reduced peripheral perfusion. Green *et al.* recommended active treatment of asymptomatic stenoses only if the combination of ABPI's and Duplex scans were abnormal; otherwise they suggested a conservative policy with intensified GS until symptoms developed and/or both parameters became abnormal.[17] As in this series, Idu *et al.* had several non-treated patients with stenoses and found that non-treatment was only safe for lesions causing up to 50% diameter reduction which gives added credence to use of the V_2/V_1 ratio during Duplex scanning.[8] Mattos *et al.* also had a number of non-treated patients with stenosed grafts in their series and concluded that whilst intervention prolonged patency, most stenosed grafts remained patent if left alone and therefore stenosis was just one factor relevant to the overall aetiology of failure.[26]

There are no universally-accepted guidelines as to the most effective modality for intervention. Most series report a mix of radiological and surgical interventions and it is generally accepted that PTA is most suited to short lesions less than 2cm.[3] In our experience, PTA provides a safe, durable and effective treatment option for stenoses and does not preclude a repeat attempt or a surgical option in the event of recurrence.

In conclusion, our data support the principles of GS, based on the assumption that every haemodynamically-significant lesion detected poses a threat to continuing graft integrity and that intervention is warranted to salvage the threatened graft before it occludes. However, this review has identified a subset of patients with "at-risk grafts" who did not have the stenoses corrected. Although no clear distinguishing factors have been identified to discriminate these stenoses from the ones which were treated, and accepting that there may be some bias due to patient selection, the results for the non-treated lesions suggest that intervention is not warranted in every case and they uphold the need for a large, prospective, randomised trial to formally establish the role of GS. The need for standardisation of protocols, criteria and modes of intervention remains outstanding.

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